

# VULNERABILITY ASSESSMENT OF SETTLEMENTS DURING EMERGENCIES

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Research article

**Abstract:** During emergencies which occur as a result of uncontrolled effects of natural disasters, major technical and technological accidents and major epidemics of infectious diseases, the health and life of people and the persistent environmental degradation may be affected. Therefore, it is necessary to assess the vulnerability of the settlements from natural disasters and other accidents. The assessment must be professionally and scientifically established with a multidisciplinary approach. This paper defines methodology for vulnerability assessment of given populated areas during emergencies arising from uncontrolled effects of natural and other disasters which involves a complex analysis of actual hazard probabilities and the level of impact on humans, animals, property, cultural wealth, and the environment.

**Keywords:** Emergency, vulnerability assessment, populated area.

## Introduction

Emergencies occur as a result of uncontrolled effects of natural disasters (floods, droughts, earthquakes, fires, etc.), of large-scale technical and technological accidents (accidents on petroleum or petroleum product installations, accidents related to transport and storage of toxic, explosive, and radioactive substances, heavy contamination of potable water springs for residential water supply, large-scale traffic accidents, mining accidents, industrial accidents caused by explosions, and radiological, biological, epidemiological, and other technical and technological accidents), and of large-scale infectious disease epidemics, epizootics, and epiphytotics (mass infections of humans, animals, and plants).

In the current research literature vulnerability is defined as a set of factors and processes which increase exposure to hazards of a certain territory or a settlement. Among factors that affect settlements exposure to hazards Constantin et al. list factors like population density, population size, land use functions, quality of construction materials and infrastructure building techniques. (Constantin, 2015)

During the past few decades vulnerability of settlements has been investigated both on national and intentional level. Various aspects were

investigated (social, ecological, economic) by different authors. (Das et.al, 2012; Wilhelmi et. al, 2013; Leurs, 2005)

A detailed review on conceptual methodologies for vulnerability assessment of population, communities and ecosystems was done by De Lunge et. al. (De Lange et. al, 2010)

This research paper presents framework for vulnerability assessment of populated areas during emergencies based on the national legislative in Serbia in the area of emergencies and laws on spatial planning development.

## Materials and methods

Assessment of vulnerability from natural disasters and other accidents is a fundamental document for creating the Emergency Safety and Rescue Plan on the national, government, local self-government, corporate, and the level of other organizations. (Official Gazette, 93/2012)

Assessment of vulnerability to unwanted events during emergencies is aimed at providing a qualitative and quantitative risk assessment based on the analysis of all the relevant parameters that act as stressors. This ensures proper creation of safety and rescue plans for natural and other disasters,

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which is necessary for adequate risk management during emergencies.

The creation of these plans has to involve the analysis that covers the following aspects:

- risks, or causes that can lead to accidents in territories for which the vulnerability assessment is made,
- possible effects of emergencies,
- establishment of an adequate organization of safety and rescue for the purpose of accident prevention and the rescue of humans, property, and cultural wealth,
- assessment of the needs and capabilities for securing humans and property necessary for safety and rescue.

Vulnerability assessment of a territory is created based on:

- all available data on natural and other disasters from the previous period or disasters that could occur in a given territory,
- potential or previous effects,
- scientific, technical, and other knowledge and achievements,
- existing expert analyses that have already been used or could be used for hazard assessment.

The assessment involves a complex analysis of actual hazard probabilities and the type, scope, and level of impact on humans, animals, property, cultural wealth, and the environment, taking into account the population density, technical and technological content of urban structures and industrial zones,

the effect of natural forces, population migration, population age, and the total resistivity of the community and its ability to deal with the hazards of natural disasters, technical and technological accidents, disasters, wars and armed conflicts, and other calamities (Official Gazette, 96/2012).

## Results

### *Methodology for assessing the vulnerability of populated areas*

The methodology for assessing the vulnerability of populated areas includes the following steps:

1. Hazard identification for a populated area;
2. Analysis of emergencies;
3. Analysis of critical institutions and buildings;
4. Analysis of indicators of social vulnerability;
5. Analysis of vulnerability of economic activities;
6. Analysis of environmental vulnerability;
7. Analysis of activities of prevention, protection, and/or mitigation of the effects of emergencies.

### *Hazard identification for a populated area*

The first step in hazard identification for a populated area is the analysis of the position and features of a given territory. Assessment of vulnerability to unwanted events due to emergencies contains data about the geographic location of the area, hydrographic and orographic features, meteorological and climatic features, population,

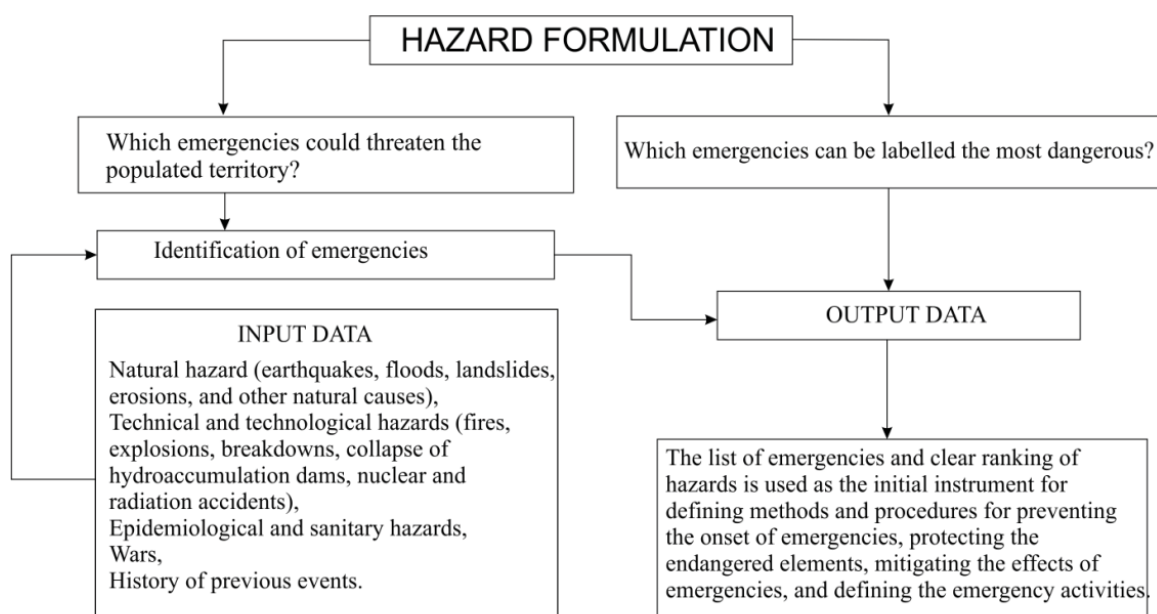


Fig. 1. Schematic representation of parameters considered in emergency identification in a populated area

property, cultural wealth, protected natural resources, fauna, water supply, agricultural surfaces, buildings for shelter and healthcare purposes, transportation and public utility infrastructure, and industrial zones. The data are taken as input data in the emergency identification stage (Fig. 1).

Hazard identification also involves the identification of potential hazards from natural disasters and other accidents, which can be classified according to their cause into natural, technical and technological, epidemiological, etc., in order to determine the vulnerability level of a populated area (Fig. 1) (Radosavljević, 2010).

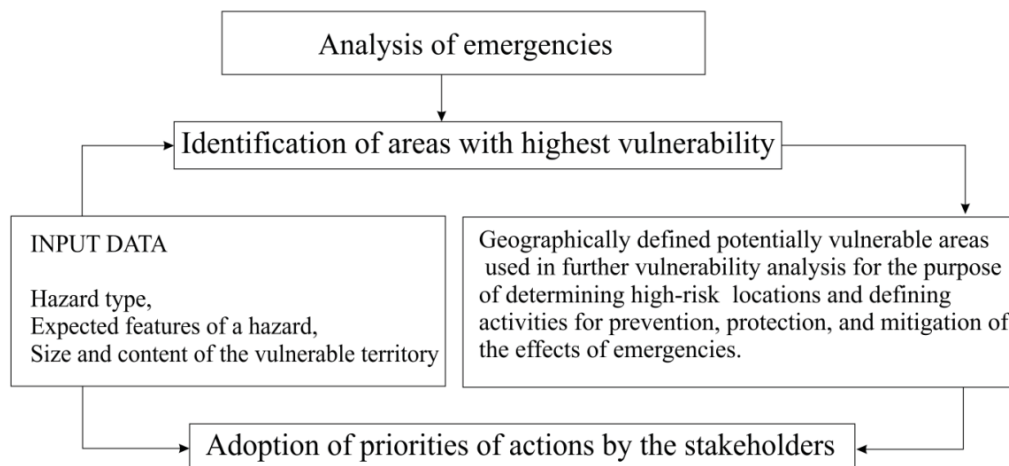


Fig. 2. Schematic representation of parameters considered in analysis of emergencies

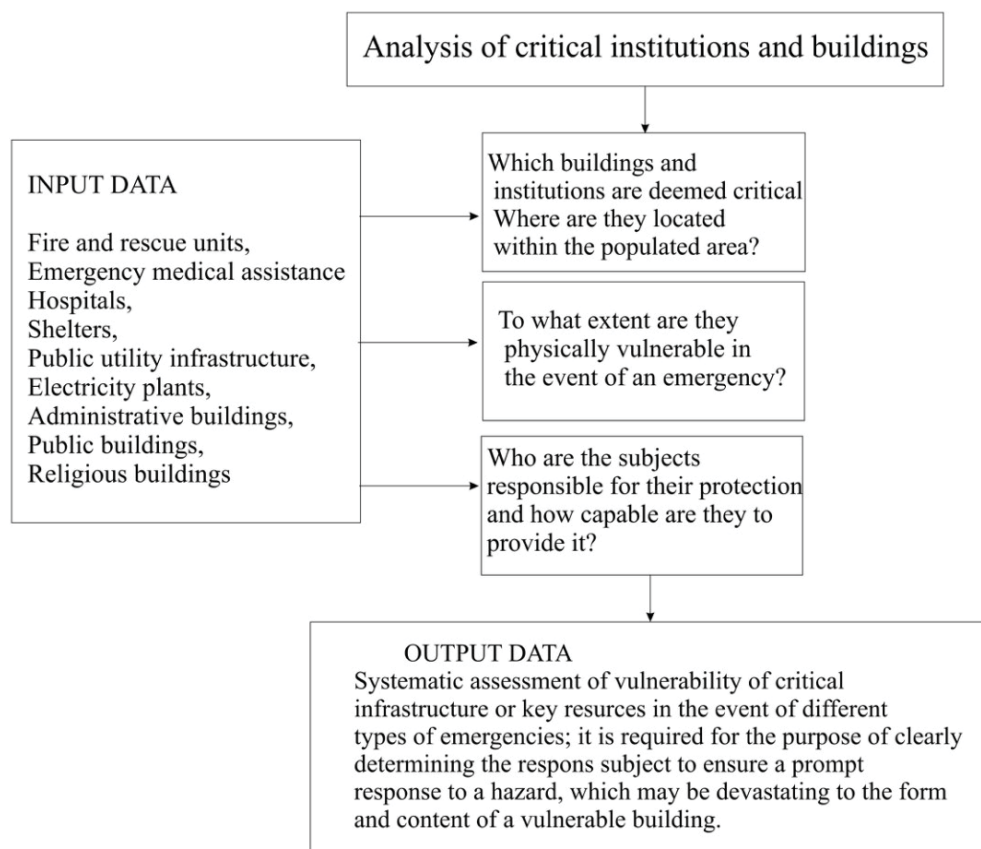


Fig. 3. Schematic representation of parameters considered in emergency analysis of critical institutions and buildings

## ***Analysis of emergencies***

Analysis of emergencies involves:

- *Clear and accurate definition of the vulnerable area.* Analysis of accident effects includes the analysis of vulnerability and the determination of the possible level of accident. Vulnerable zones in maps are shown through a delineation of hazards. Actions such as collection of statistical data or comparison of past events are used for the purpose of making decisions that will best help utilize the capacities for combating hazards in a given territory (Fig. 2).
- *Ranking of vulnerable areas.* This procedure is used to quantify the hazard and clearly determine the priority of actions (Fig. 2) (Radosavljević, 2010).

## ***Analysis of critical institutions and buildings***

Analysis of critical institutions and buildings involves the position and characteristics of the location of buildings, facilities, and infrastructure; activities; usage and purpose of surfaces; surroundings; population number; surrounding vulnerable buildings; schools; kindergartens; etc.

The classification of critical institutions and buildings into categories serves to determine the vulnerability of important institutions, buildings,

or resources of a populated area. This analysis is to be used to create operative maps of critical building and institution protection (Fig. 3) (Radosavljević, 2010).

## ***Analysis of indicators of social vulnerability***

Analysis of indicators of social vulnerability involves the identification of parts of a populated area with the most socially vulnerable residents and their vulnerability in case of an emergency (Fig. 4) (Radosavljević, 2010).

## ***Identification of areas of special significance***

In terms of human settlements, areas of special significance are locations where the possibilities of individual emergency response are minimal or highly limited. Regeneration of such areas after an emergency mostly, and sometimes even entirely, depends on the government's help. (Radosavljević, 2010)

## ***Analysis of vulnerability of economic activities***

Analysis of vulnerability of economic activities involves identifying the locations of hazardous and harmful materials within a populated area, analyzing the safety of buildings that house hazardous and

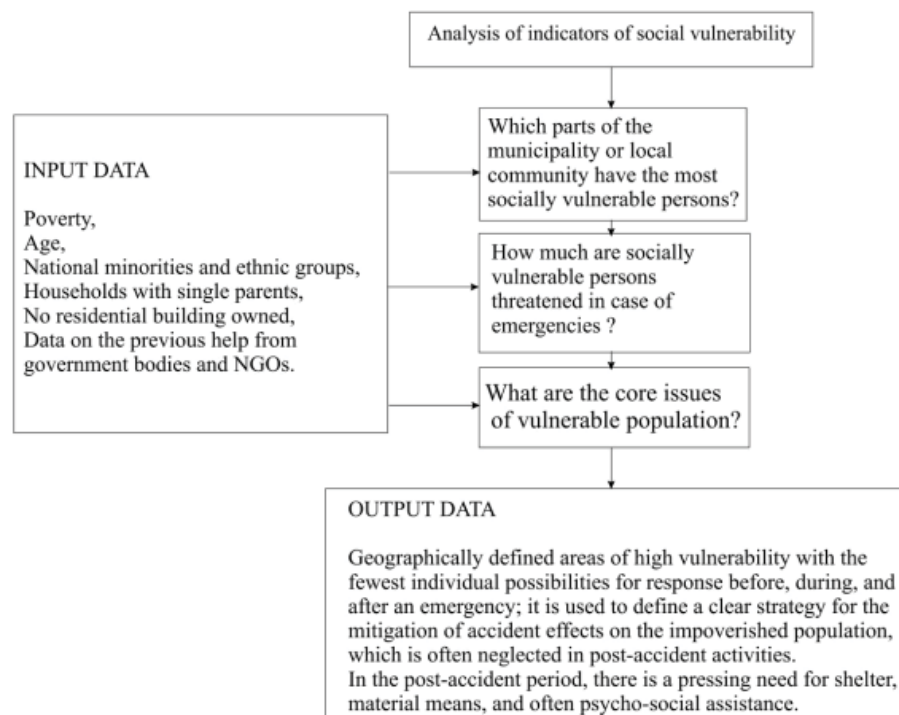


Fig. 4. Schematic representation of parameters considered in emergency analysis of indicators of social vulnerability

harmful materials during emergencies, etc (Fig. 5) (Radosavljević, 2010).

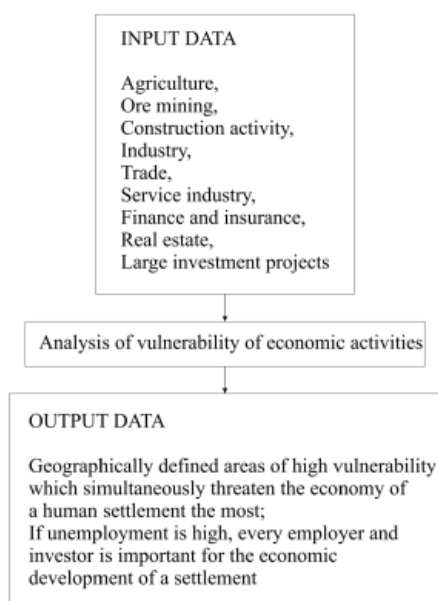


Fig. 5. Schematic representation of parameters considered in emergency analysis of vulnerability of economic activities

path (to a subject or object), and the vulnerability of a subject or object due to the stressor (Fig. 6) (Radosavljević, 2010).



Fig. 6. Schematic representation of the analysis of environmental vulnerability during emergencies

### *Analysis of environmental vulnerability*

This analysis uses the applicable laws pertaining to environmental protection and the relevant international recommendations. The most commonly used concept in the assessment of environmental risk is the one that defines the stressor source, the stressor

### *Analysis of activities of prevention, protection, and/or mitigation of the effects of emergencies*

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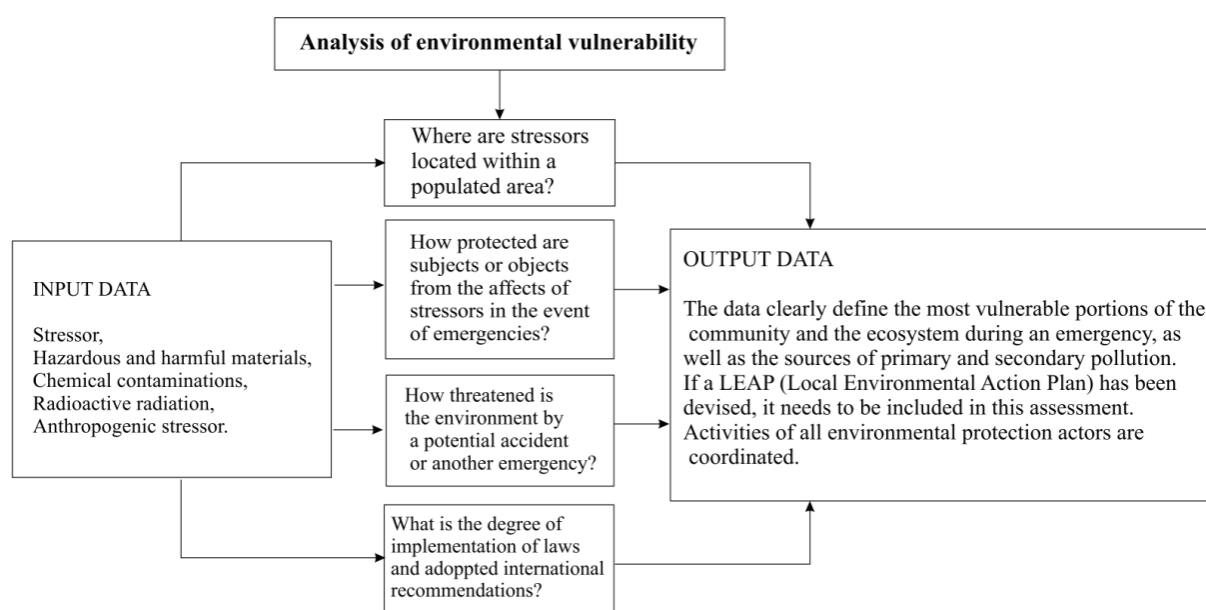


Fig. 7. Schematic representation of parameters considered in emergency analysis of environmental vulnerability



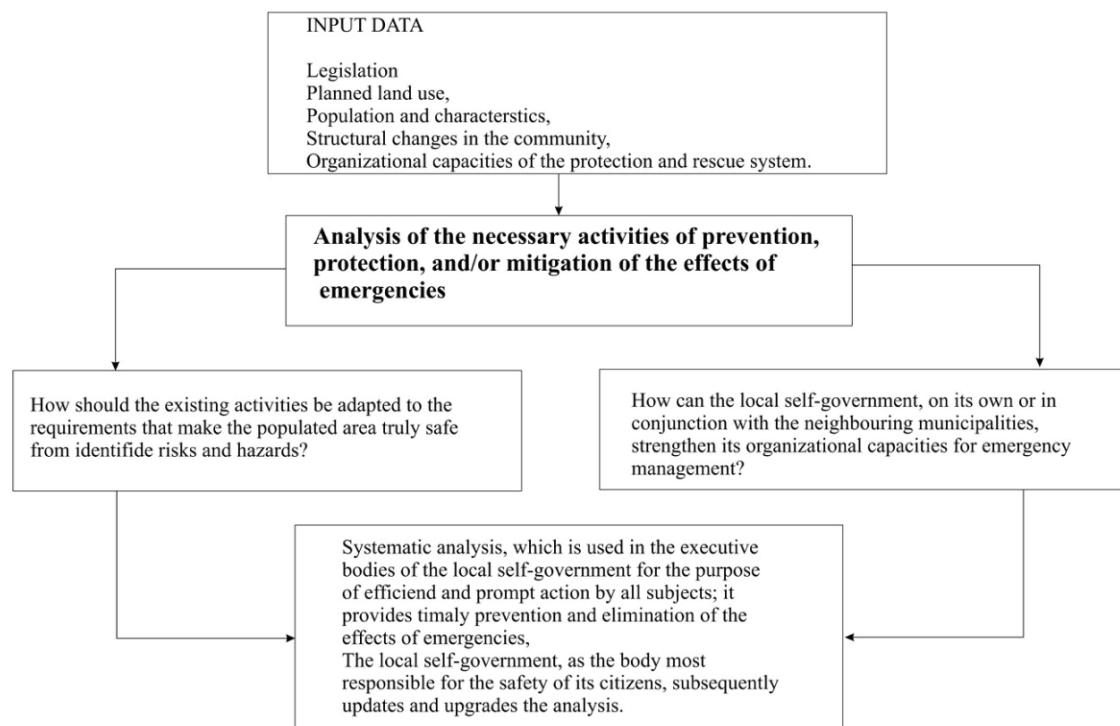


Fig. 8. Schematic representation of parameters considered in emergency analysis of activities of prevention, protection, and/or mitigation of the effects of emergencies

should suggest the ways in which the existing activities are to be adapted to the requirements that make the populated area truly safe/protected from identified risks and hazards.

The Law on Protection and Rescue defines the term “emergency management” (Radosavljević, 2010). This implies on determining the basic goal of the protection and rescue system. Emergency management phases include prevention, readiness, response, rehabilitation and mitigation. The prevention phase includes activities to eliminate the causes of potential hazards in a particular territory. The readiness phase includes the development of emergency plan, recruitment and training of staff, identification of supplies, etc. In the state of emergency, the response phase involves the implementation of activities predicted by emergency plan and hazard reduction services such as order establishment in an endangered territory, activities in healthcare supervision, rehabilitation of infrastructure as well as informing the citizens in case of need. The goal of rehabilitation is to restore activities in the settlement as soon as possible. The mitigation includes activities that should reduce or eliminate risk for population, their property, material and cultural goods and the environment (Radosavljević, 2010). After the implementation of certain plans of protection and rescue from natural

and other disasters, the process does not end. It requires a constant analysis of the efficiency of the applied methods and in some way the Plan is constantly innovated. (Radosavljević, 2010)

## Conclusion

Vulnerability assessment of a populated area during emergencies is the starting point for successful planning and implementation of safety and rescue measures, as well as mitigation and elimination of the effects of emergencies. Assessment of a settlement’s vulnerability due to stressors caused by emergencies encompasses and analyzes all the important statistical and other data on human, material, cultural, and other resources available in a given settlement, as well as the possible types and degrees of vulnerability. If the assessment is adequate, it is possible to objectively determine the most appropriate measures and procedures, which will provide the most efficient action during emergencies. Vulnerability assessment of a populated area during emergencies is performed according to the adopted methodologies, which are scientifically based, which acknowledge the profession, and which involve a multidisciplinary approach.

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